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V. I. Monchenko, Acad. of the NAS, Ukraine [1,2]

[1]I.I.Schmalhausen Institute of Zoology, National Academy of Sciences of Ukraine, Kiev, Ukraine
[2]National Museum of Natural History, National Academy of Sciences of Ukraine, Kiev, Ukraine

CYCLOPINIDAE (COPEPODA) IN THE SEA OF AZOV (GENERAL CONCLUSIONS)

The illustrated monographic descriptions of species of Cyclopinidae from the Sea of Azov are presented. They were not recorded in this Sea earlier. The males of *Cyclopinoides littoralis* are described on the whole at first time. Among different biotopes the interstitial is the most preferred one for representatives of Cyclopinidae. These species are found in 90 samples from 172 ones digged up at the 35 geographic sites of the coastal zone. Perhaps 122 from them were taken actually at typical for this sea mesohaline salinity. Salinity preferendum (polyhaline, pleuomesohaline and meiomesohaline ones) for each species is ascertained. The row of significant meristic features for differentiation of Azov-Blacksea populations of *Cyclopina esilis major* from type populations of Mediterranean and Atlantic C. *gracilis (*except the more large dimensions) is proposed.

Key words: The Sea of Azov, Cyclopinidae (Copepoda), biodiversity, species redescriptions, halopathy, systematic

The Sea of Azov completes a long geographic succession of five "gulfs" from the Atlantic ocean, with gradual total salinity decreasing. It causes consecutive reduction of a species biodiversity in the marine family Cyclopinidae from 28 species in the Atlantic ocean to 25 in the Mediterranean Sea through 10 in the Black Sea and up to 4 in the Sea of Azov. The chain ends in the Caspian Sea, where only one genus and species of this family, *Cryptocyclopina inopinata* Monchenko (in spite of great volume of own investigated materials), is known. This distinct sequence in reduction of species biodiversity in connection with salinity diminution was tracked by me and recently published [13]. However this regularity has been expressed only in the alteration in species lists. The species peculiarities were not shown, especially in the Sea of Azov. These data have not been generalized; there were no indications on morphological variability of species at different level of salinity. On the whole, these data were not presented in monographic descriptions of the species, customary as a rule.

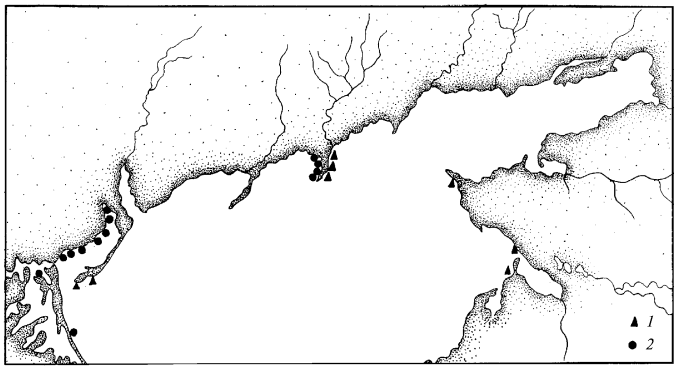
Cyclopinidae is such a group of invertebrates, the investigations of which is very scars. So, from 325 invertebrate species, known to 1960 in the Sea of Azov [14], they were represented by the only two genera: *Cyclopina* and *Cyclopinoides*. *Cyclopina* sp. from Kuban estuaries [7] was incorrectly related by author to *C. gracilis*, because the other species of the same genus in that time were not known. Others materials concern to Cyclopinidae in the Sea of Azov in the report of F. D. Mordukhai-Boltovskoi [14] were absent.

In our paper these incompleteness of mentioned investigations were eliminated, and morphological materials with illustrations are presented in full. Here for the first time the keys for species, genera and families identification are given and monographic descriptions of taxa together with tabulated materials with the measurements of systematic characteristics to differentiate described species are resulted also.

Materials and Methods. The materials were collected at the coasts of the Sea of Azov along perimeter of the sea by the help of wireframe boat during 1968, 1970 – 1972, 1974, 1978 – 1980. The materials were sampled in 35 geographical sites of the coast (Map 1), more or less evenly arranged along sea perimeter.

From 172 digged up interstitial and coastal samples 122 ones are taken actually at mesohaline salinity usual for the Sea of Azov (without brackish waters of Taganrog Gulf and other estuaries). The representatives of the family Cyclopinidae were found in 90 samples. The salinity characteristics are realized by $AgNO_3$ titration with converting to chloric coefficient 1.8.

Map 1 Sites of investigations of Cyclopinidae in the Sea of Azov
Карта 1 Районы исследования Cyclopinidae в Азовском море



Map 2 Localities of *Cyclopina hadzii* (*1*), *C. gracilis* and *C. esilis* (*2*) in the Sea of Azov:
Карта 2 Распространение *Cyclopina hadzii* (*1*), *C. gracilis* and *C. esilis* (*2*) в Азовском море

Results and Discussion. The Cyclopinidae are found by me in 90 samples (occurrence 73.7 %) (Table 1).

Table 1 Occurrence of Cyclopinidae in mesohaline coastal waters in the Sea of Azov.
Табл. 1 Встречаемость Cyclopinidae в мезогалинных прибрежных водах Азовского моря.

Species	Absolute number of samples	Relative occurrence, %
Cyclopinoides littoralis (Brady)	4	3.28
Cyclopina gracilis Claus	12	9.84
C. esilis Brian	20	16.4
C. hadzii Petkovski	13	10.7

Among varied interstitial copepods of different families *Cyclopina esilis* is considered as ecologically subdominant species, recorded in every fourth – sixth sample of interstitial (occurrence 16.4 %). Enough usual were two other species, with frequencies 9.8 – 10.7 % (*C. gracilis* and *C. hadzii*). The rare in the Sea of Azov *Cyclopinoides littoralis* was met in 3.28 % of samples with peculiar distribution (see further).

However, average frequency of occurrence reflects the species distribution on coasts only in general. The main proper for distribution of Cyclopinidae along the perimeter of the Sea of Azov is the gradient of salinity of the site and halopathy of species. So, *Cyclopina esilis* and *C. gracilis* penetrate along the northern coast to the east only to Berdyansk split (Map 2).

Last split is the specific ecological border for Cyclopinidae coastal fauna in this sea. Collecting the materials on this split during any above mentioned years, I have noticed that prevailing northeast and east winds, making up for water from more fresh areas (Taganrog Gulf) reduced the salinity on east coast of the split up to average 7.8 ‰. Meiomesohaline species *C. hadzii,* characteristic for the Sea of Azov, inhabits only this eastern side of the split. On the western coast the salinity remains on level of 11 – 11.5 ‰ as eastern sea waters are reflected by the split, effluent in the high sea. These west coasts are occupied densely (Map 2) by *C. gracilis* and *C. esilis* (enough usual for the Black Sea). Last both species dominate in taxocen of Cyclopinidae in upper Utluk gulf (Map 2), where the salinity arise up to 30.9 ‰ (according my measurements), and also in Sivash in Genichesk's area (14.4 ‰). The Black Sea character for the Sea of Azov fauna gives the occurrence here also *Cyclopinoides littoralis*, found by me in the Sea of Azov, besides only in southern areas (Arabat and Kazantip gulfs) (Map 3). As a whole the Sea of Azov disposes considerable extensive interstitial spaces with favorable conditions for inhabiting of Cyclopoida living in sand-shell rock sediments, as against mainly stony coasts in the Black Sea. It, probably, explains the higher parameter of frequency of the general occurrence of group in the interstitial of the Sea of Azov – 73.3%, as compared to 46.7 % in the Black Sea.

Map 3 Localities of *Cyclopinoides littoralis* on the shores in Black Sea and Sea of Azov
Карта 3 Встречаемость *Cyclopinoides littoralis* в Чёрном и Азовском морях

But the lowered salinity in the Sea of Azov is unfavorable factor for marine Cyclopinidae, therefore some polyhaline Black Sea species are absent here. So, *Cyclopinoides littoralis* met in the Sea of Azov (Map 3) approximately with the same frequency, as in the Black Sea, due to their development in a northwest and western part of Azov, especially in Utluk gulf. The other species give obvious preference to the Sea of Azov, e.g. *Cyclopina hadzii* mets here in 10 times more often, than in the Black Sea.

It is interesting to continue the comparison between the frequency data of Cyclopinidae in the Sea of Azov and the Black Sea (Table 2).

Table 2 Comparative frequency of occurrence Cyclopinidae in the Black Sea and Sea of Azov , %
Табл. 2 Сравнительная частота встречаемости Cyclopinidae в Черном и Азовском морях, %

Species	Relative occurrence	
	Black Sea	Sea of Azov
Cyclopinoides littoralis (Brady)	4.81	3.28
Cyclopina gracilis Claus *	7.90	9.84
C. esilis Brian *	8.93	16.4
C. hadzii Petkovski	1.03	10.7

*Met in the Black Sea with relatively similar frequency

This comparison may replenish the ecological data near for each species. So, the distribution of *Cyclopinoides littoralis* almost evenly along all the shores of the Black Sea (Map 3) and its finding only in south and west (more saline) regions of the Sea of Azov testify undoubtedly about full adaptation of this species to polyhaline salinity of the Black Sea (Map 3).

Enough close quantitative frequency characteristics in both seas has *C. gracilis* (7.9 and 9.8 %). It testifies about absence of clear preferences among sites and its wide halopathy. But exact different are this features for *C. esilis* (2 times more frequent in the Sea of Azov, than in the Black Sea) and especially for *C. hadzii* (10 times to count in favor the Sea of Azov). These last facts speak about strong preference of both species, especially the last one, to meiomesohaline brackish waters.

From zoological point of view the discovery of representatives of the family Cyclopinidae in the Sea of Azov on the whole enrich known earlier faunal data. Among the mentioned species there are new not only for fauna of actually Sea of Azov (*Cyclopina gracilis*, *Cyclopinoides littoralis* etc.), but also for fauna of the Black Sea (*Cyclopina esilis*) and former Soviet Union (*C. hadzii*). Almost all of them on the whole are very rare species.

Mentioned for the first time for fauna of the country and Sea of Azov, *C. hadzii* found the second time after its first description under this name near Dubrovnik on Adriatic Sea [15]. It was incorrectly specified as *C.* cf. *steueri* [16]. It is nowadays found out in 13 sites on the Sea of Azov coast and in three sites in the Black Sea.

Key to families of the order Cyclopoida

1 (2) Mandibular palp reduced to a papilla, bearing three setae at most…….. .. ……Cyclopidae Sars, 1913
2 (1) Mandibular palp well-developed, polisegmented
3(4) Antenna 2- to 3-segmented
……..…..Oithonidae Dana, 1854
4(3) Antenna 4-segmented (except subfam. Pterinopsyllinae)…..… ……... Cyclopinidae Sars, 1913

Key to the genera of the family Cyclopinidae in the Sea of Azov

1 (2) P5 in female 2-segmented
……..……..……*Cyclopina* Claus
2 (1) P5 in female 3-segmented
…..……..……*Cyclopinoides* Lindberg

Genus ***Cyclopinoides*** Lindberg

Cyclopinoides Lindberg, 1953: 317; Vervoort, 1964: 29; Wells, 1967: 199; Jaume et Boxshall, 1997: 98; Dussart et Defaye, 2001: 232; Boxshall et Halsey, 2004: 513.

Antennula 18 to 20-segmented. Exopodite of antenna representes by one or two setae. Palp of mandible made of 4-segmented exopodite and 2-segmented endopodite. Endopodite of maxilliped at least 4-segmented. Spines formula of PI to P4: 3-4-4-2 (except in *C. bisetosa:* 4-4-4-2). Setae formula: 5-5-5-5 (except in *C. bisetosa*: 4-5-5-5). Distal spine on outer edge of Exp3 P4 replaced by a seta. Endopodite 2 of PI with one seta. Endopodite 1 of P4 with strong and thick seta. P5 3-segmented (4-segmented in male), the first one without a seta, and the third with four appendages.

Type species *C. longicornis* (A. Boeck, 1872)

The genus counts 4 marine species. In the south seas of formerly Soviet Union is known only *C. littoralis* (Brady, 1872).

Cyclopinoides littoralis (Brady) (fig. 1 – 3)

- *littoralis* Brady, 1872: 5 (*Cyclops*); Giesbrecht, 1901: 43 (*Cyclopina*); Kiefer, 1929: 15; Lang. 1946: 1; Lindberg, 1953: 322 (*Cyclopinoides*); Monchenko, 1977: 20; 2007: 555.

Materials. Sea of Azov: 1) Utluk gulf, thickets of Zostera, 25 ‰, 24.VIII.1980, 4 females, 8 males, 10 juv. (Monchenko); 2) Sivash at Genichesk, thickets of Zostera, 27.VII.1980, 4 females, 1 male (Monchenko); 3) Arabat gulf at village Semenovka, interstitial, 40 l, 8.IX.1974, 1 female (Monchenko) etc., totally 4 sites.

Black Sea: 1) Sevastopol, interstitial, 40 l, 18 ‰, 20^0 C, 10.XII.1976, 3 females, 1 male, 1 juv. (Monchenko); 2) Simeiz, Crimean region, interstitial, 40 l, 28.VI.1975, 9 females, 11 males, 6 juv. (Monchenko); 3) Island Tendra, interstitial, 40 l, 5.VII.1971, 2 females (Monchenko), etc., totally 10 sites.

Female. The total length 673 – 710 μm. Cephalothorax wide, frontal part of syncephalon oval; abdomen narrow and slender (fig. 1, *1*). Back edges of somites smooth. First pedigerous somite is clearly separated from syncephalon. The fifth thoracal and genital double-somite of characteristic outlines (fig.1, *2*). The length of the last 1.25 times exceeds width. Slender caudal rami slightly divergent, their length 4.0 – 5.0 times more than width. The relative length of all setae is visible from fig.1, *1, 3*.

18-segmented antennula exceeds 2/3 lengths of syncephalon (fig. 1, *4*), they are densely covered by downy setae; on distal segment – long sensory appendage. 4-segmented antenna with outer seta of exopodite (fig. 1, *5*). Well developed palp of mandible (and maxillule) is presented on fig. 1, *6* and 2, *1*, their abundant armament is rather usual for Cyclopinidae, e.g. maxillula (fig. 2, *1*) with well developed exopodite and endopodite.

Maxilla with rich rigid armament (fig.2, *2*). Maxilliped with 4-segmented endopodite, segments of which are armed as follows: 1, 2, 2, 3 (fig. 2, *3*). Swimming legs P1 – P5 are presented on fig. 2, *4*, *5* and 3, *1*. Their segmentation 3/3, 3/3, 3/3, 3/3. Inner setae of coxopodites short, except for P1. The inner appendage of basipodite P1 spineformed, hardly reaches the end of the second segment of adjacent endopodite. The formula of spines on distal segments of exopodites of P1 – P4 4-4-4-2; the spines extended, lanceolate; quantity of setae on these segments 4-5-5-5. The first segments of endopodites and the second segment of endopodite P1 bearing all on one seta, the setae of the first segments of P2 – P4 are strong thickened (fig. 2, 5 and 3, *1*).

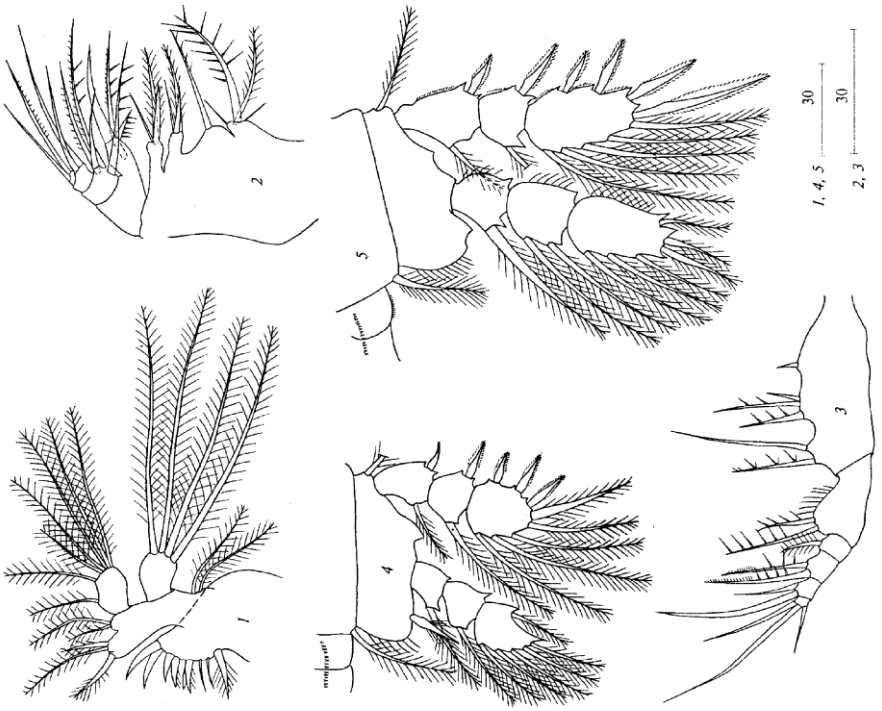


Fig. 2 *Cyclopinoides littoralis*, ♀: *1* – maxillule with the palp; *2* – maxilla; *3* – maxilliped; *4*, *5* – swimming legs P1- P2.

Рис. 2 *Cyclopinoides littoralis*, ♀: *1* – максиллула со щупиком; *2* – максилла; *3* – максиллипеда; *4*, *5* – плавательные ноги P1 – P2

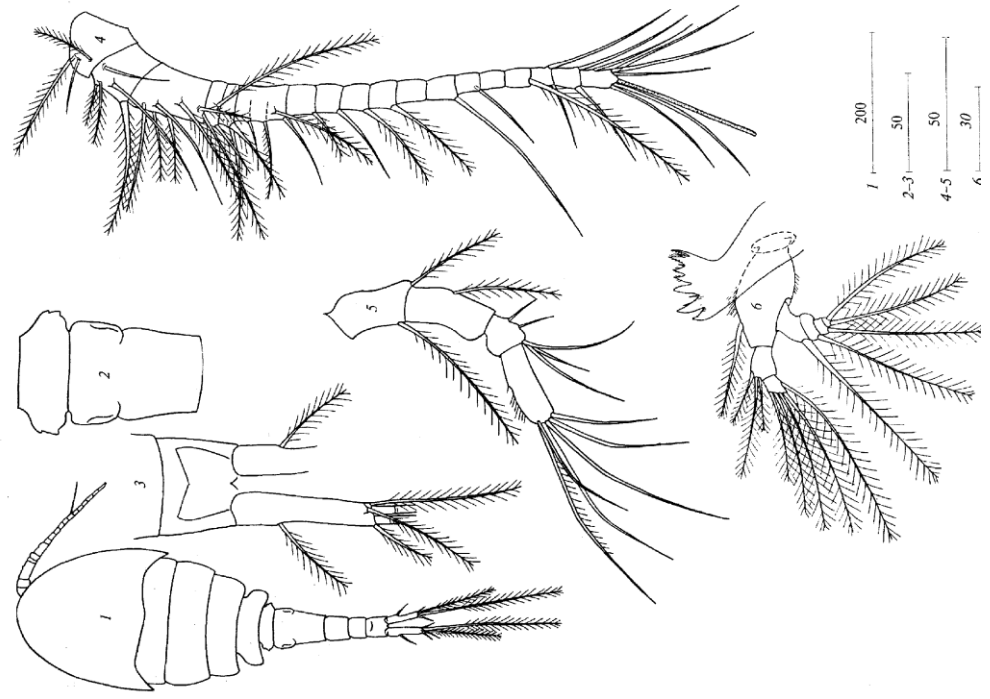


Fig.1 *Cyclopinoides littoralis*, ♀: *1* – habitus, dorsal; *2* – genital double-somite; *3* – caudal rami, dorsal view; *4* – antennula; *5* – antenna; *6* – mandible with the palp. Scale bar in µm.

Рис.1 *Cyclopinoides littoralis*, ♀: *1* – общий вид, дорсально; *2* – генитальный сомит; *3* – каудальные ветви, дорсально; *4* – антеннула; *5* – антенна; *6* – мандибула со щупиком. Все масштабные линейки в микрометрах.

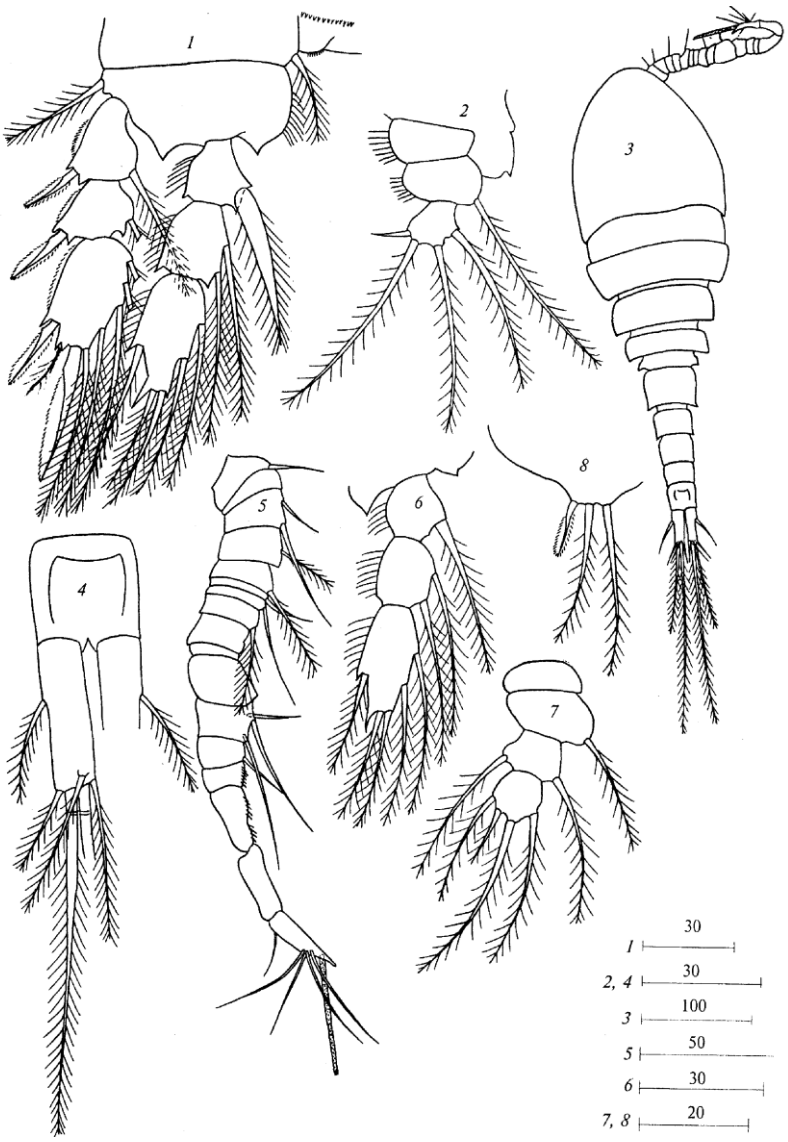


Fig. 3 *Cyclopinoides littoralis*, ♀: *1* – P4; *2* – P5. ♂: *3* – habitus, dorsal; *4* – caudal rami, dorsal view; *5* – geniculated antennula; *6* – endopodite of P4; *7, 8* – P5 – P6.

Рис. 3 *Cyclopinoides littoralis*, ♀: *1* – P4; *2* – P5. ♂ *3* – общий вид, дорсально; *4* – каудальные ветви, дорсально; *5* – геникулирующая антеннула; *6* – эндоподит P4; *7, 8* – P5 – P6.

The second segments of endopodites of P2 – P4 with two setae. The third segments of endopodites P1 – P3 with 6 setae everyone, and P4 – with 5 setae; from which two apical approximately are identical in length and equal to length of segment. This segment slender elongated, its length 1.8 – 1.9 times exceeds the width. P5 3-segmented; the first segment is deprived the armament, the second – with one outer seta and the third – with three setae.

Male. The total length 477 μm (fig. 3, *3*). Caudal rami are a little bit shorter (an index 3.2), than in females, with rather similar armament (fig. 3, *4*). Geniculated antennula 16-segmented (fig. 3, *5*). The proportions of P4 are seen on fig. 3, *6*). P5 with additional seta on the first and the second segments (fig. 3, *7*). P6 is given on fig. 3, *8*). The male is described in first time. The presented description of this species is the fullest in the literature. One of the best former descriptions [17] doesn't include the structure of oral appendages and morphology of male, shown by me in details.

Distribution. The geographic range of this species has the distinct character. On the one hand, it inhabits coastal areas of the Arctic basin and boreal Atlantic, with the other two-three sites in Mediterranean Sea [8, etc.].

In the Black Sea I have found this species in 10 sites (Map 2) at coast of the Black Sea: twice in northwest part of the sea in Tendra gulf, in five sites of the Crimean coast, from village Mezhvodnoye to Simeiz [13] and in three sites of the Caucasian coast: Anapa, Gelendjik bay, Batumi. It was found at south shore of Crimea [22]. It has been recorded also twice [1, 19] and mentioned in one of estuaries near Odessa.

Besides the species for the first time is found out by me for the Sea of Azov fauna – in Arabat gulf (at villages Semenovka) and Mysovoye, in upper part of Utljuk gulf and in so called Rotten Sea (Sivash) [11].

Ecology. In 8 of 14 cases I recorded this species in interstitial biotope (pebbly beach at Crimea, the Caucasian coast) or a shell rock (Sea of Azov, in the Black Sea – Anapa, Gelendjik). Besides species is found by me on sea macrophytes of different species (*Zostera*, *Cystoseira*, etc.). According to other authors, the species meets up in rather various biotopes. I did not meet it outside of polyhaline waters. It is remarkable, that in the Sea of Azov the species is found only in its southern most salty part, at salinity more than 20 ‰ in upper Utlyuk gulf.

Genus ***Cyclopina*** Claus

Cyclopina Claus, 1863: 103; Giesbrecht, 1900: 41; Sars, 1913: 10; Kiefer. 1929: 13; Pesta, 1928: 77; Gurney, 1933: 8; Sewell, 1949: 22; Lindberg, 1953: 318; Vervoort, 1964: 28; Wells, 1967: 199; Jaume et Boxshall, 1997: 99; Dussart et Defaye, 2001: 114, 229; Boxshall et Halsey, 2004: 515.

Antennula 10-13-segmented. Antennal exopodite presented by 1 seta. Exopodite of mandibular palp with 4 segments, endopodite with 2 segments. Endopodite of maxilliped 4-segmented (rare 3). First pedigerous somit fused with syncephalon. Spine formula of swimming legs 4-4-4-3 (rare 3-4-4-3), seta formula 4-5-5-5 (rare 4-5-4-4). 2-nd segment of endopodite P1 with 1 seta. P5 2-segmented (in males 3-segmented), first segment with 1 outer seta, distal segment with 3 appendages (3 – 5 in males).

Type species *C. gracilis* Claus. It is known 17 species [3] or 22 species [19]. I count 24 species. Marine, partly brackish water.

Key to the species of the genus *Cyclopina* Sars in the Sea of Azov

1 (2) Outer spine on P5 2.6 – 3.0 times longer than inner spine……*C. esilis* Brian
2 (1) Outer spine on P5 is equal length with inner one or only 1.1 – 1.2 times longer
3 (4) Endopodite maxilliped 3-segmented; endopodite P1 with 5 setae……*C. hadzii* Petkovski
4 (3) Endopodite maxilliped 4-segmented, endopodite P1 with 6 setae ……*C. gracilis* Claus

Cyclopina gracilis Claus (fig. 4 – 6)

– *gracilis* Claus, 1863: 104 (*Cyclopina*); Giesbrecht, 1900: 45; Sars, 1913: 11; Kiefer, 1929: 16; Pesta, 1928: 77; Ulomsky, 1940: 168; Lindberg, 1953, 324; Vervoort, 1964: 30; Wells 1973: 144; Grainger et Mohammed, 1991: 2372; Dussart et Defaye, 2001: 229.

– *norvegica*, Giesbrecht 1900: 45 (non Boeck) (*Cyclopina*).

Materials. Sea of Azov: 1) Berdyansk split, interstitial, 40 l, 23.VIII.1979, 97 females, 9 males, 42 juv. (Monchenko). 2) Utljuk river-liman, depth 0.5 – 1.5 m, thickets of Zostera, filamentous algae, S = 12 – 23 ‰, 21 – 27.VIII.1980, >100 females, 65 males, 16 juv. (Monchenko). 3) Sivash at Genichesk, depth 1.0 m, thickets of filamentous algae, 27.VIII.1980, 3 females, 2 juv., etc., totally 10 sites (Monchenko).

Black Sea: 1) Island Tendra, interstitial, 40 l, 5. VIII.1971, 20 females, 2 males, 10 juv. (Monchenko). 2) Crimean region, Simeis, Ponizovka, interstitial, 40 l, 30. VII.1975, > 100 females, 29 males, 13 juv. (Monchenko). 3) Bay Kamyshovaya near Sevastopol, interstitial, 40 l, 8. IX.1976, 7 females, 2 juv. (Monchenko). 4) Sochi, river Buzgu, interstitial, 40 l, 5 females, 3 males, 3 juv. (Monchenko); totally 22 sites (Monchenko).

Female. Total length 356 – 388 μm. Body moderately slender (fig. 4, *1*), with the cephalothorax oval in form, greatest width exceeding half of the length and occurring about in the middle. First pedigerous somit fused with syncephalon in cephalothotax. Abdomen with the genital double-somit rather slender, it consists 49 – 55 % of prosome length (fig. 4, *2*). The posterior edges not serrate. Genital double-somit enlarged in anterior part, with two lateral denticles. Its length 1.08 – 1.29 times is more than maximal width. Caudal rami parallel, widely arrange (fig. 4, *3*), length/width ratio 3.3 – 4.0. Lateral seta placed in front of the middle. Apical setae of moderate length. Each from them consists in per cent from caudal rami length:

dorsal seta 78 – 90 (average 83 %), n = 6;
innermost seta 90 – 120 (average 103), n = 10;
inner middle seta 342 – 400 (average 376), n = 10;
outer middle seta 208 – 245 (average 227), n = 10.

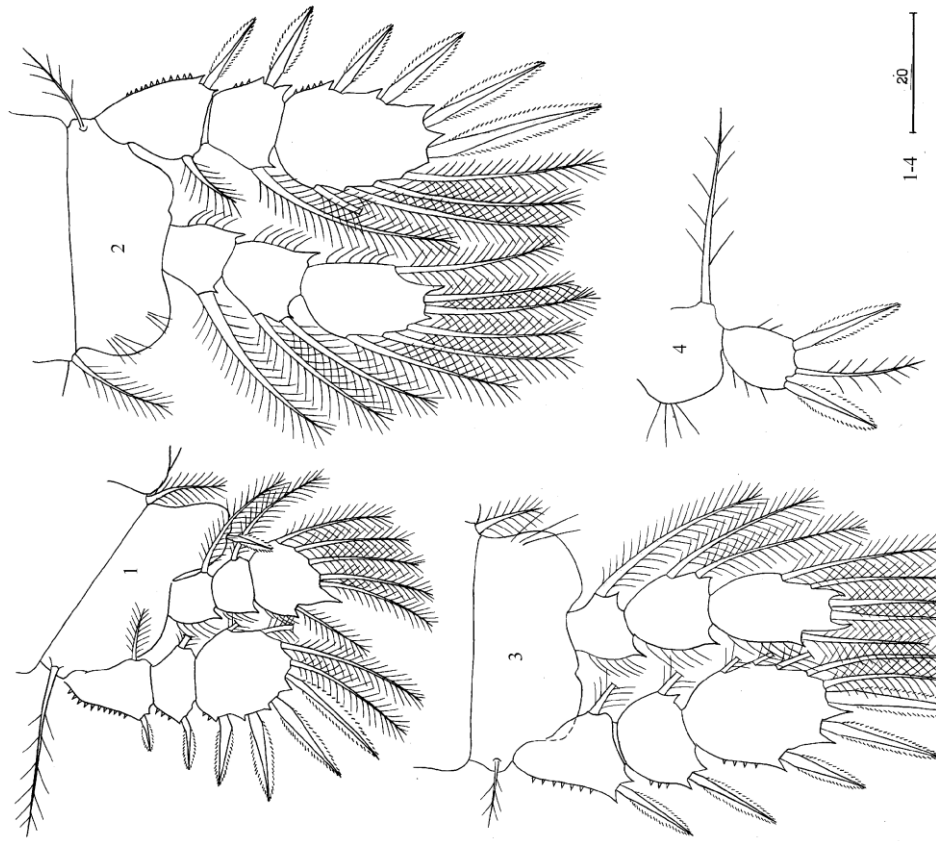


Fig. 5 *Cyclopina gracilis*, ♀: *1-2* – P1 - P2, *3 – 4* – P4–P5.
Рис. 5 *Cyclopina gracilis*, ♀: *1-2* – P1 - P2, *3 – 4* – P4–P5.

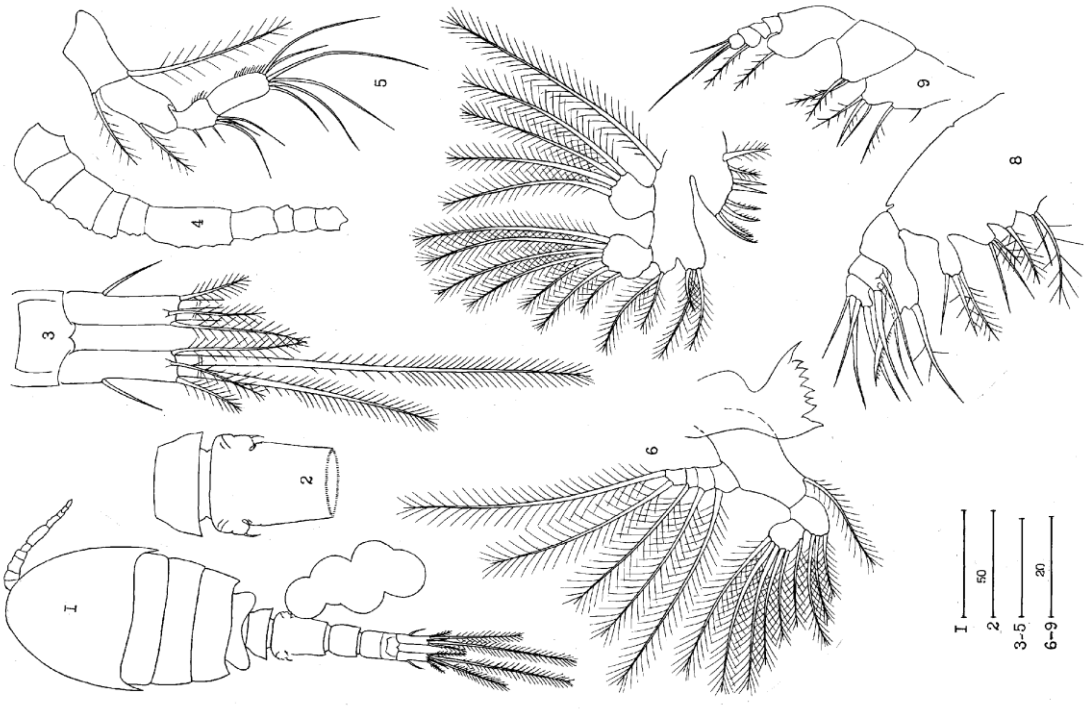


Fig. 4 *Cyclopina gracilis*, ♀: *1* – habitus, dorsal; *2* – genital double-somite; *3* – caudal rami, dorsal view; *4* – antennula; *5* – antenna; *6* – mandible with the palp; *7* – maxillule with the palp; *8* – maxilla; *9* – maxilliped.
Рис. 4 *Cyclopina gracilis*, ♀: *1* – общий вид, дорсально; *2* – генитальный сомит; *3* – каудальные ветви, дорсально; *4* – антеннула; *5* – антенна; *6* – мандибула со щупиком; *7* – максиллула со щупиком; *8* – максилла; *9* –

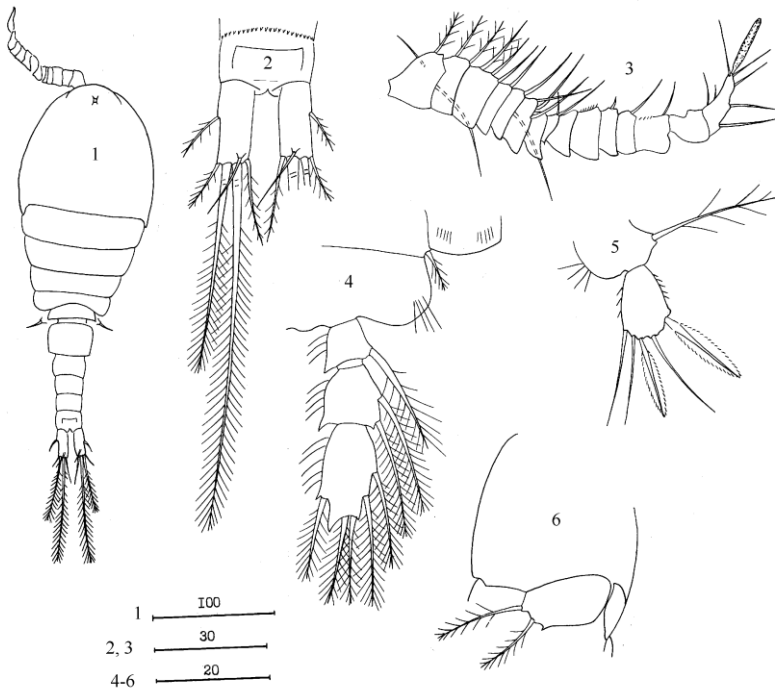


Fig. 6 *Cyclopina gracilis*, ♂: *1* – habitus, dorsal; *2* – caudal rami, dorsal view, *3* – geniculated antennula; *4* – endopodite of P4; *5-6* – P5 – P6.
Рис. 6 *Cyclopina gracilis*, ♂: *1*– общий вид, дорсально; *2* – каудальные ветви, дорсально; *3* – геникулирующая антеннула; *4* – эндоподит P4; *5, 6* – P5 – P6.

I add to these diagnostic indices some not less important ones.

Innermost seta makes 146 – 204 % (an average 180 %, n=8) lengths of outermost one, the inner middle seta – 161 – 177 % (an average 166, n = 10) lengths of outer middle one. In all resulted indices the species forms precise morphological hiatus with *C. esilis*, from which it usually differs by difficultly examined spines of P5 (see further). Short 10-segmented antennula hardly reaches the middle of syncephalon (fig. 4, *1*, *4*). Antenna 4-segmented with long seta – a vestige of basipodite (fig. 4, *5*). Mandible with well developed palp, consisting from 2-segmented endopodite and 4-segmented exopodite with armature as illustrated (fig.4, *6*). Gnathobase of maxillule with the thin slightly delayed appendages; endites with three and two setae but exo-and endopodite with 7 and 4 setae, accordingly (fig. 4, *7*). Maxilla with not divided praecoxo- and coxopodite, bearing in total 4 endites; endopodite 2-segmented, with 3 and 4 appendages accordingly (fig. 4, *8*). Maxilliped with precise border between praecoxo- and coxopodite, with 4-segmented endopodite bearing setae only on two distal segments: 1 and 3 setae (fig. 4, *9*).

Coxopodites of swimming legs without an ornament, with rather short inner setae; basipodites with outer setae more shorter and shorter from P1 to P4, with very short lanceolate spine on large inner blade of basipodite (fig. 5, *1* – *3*). Legs 1-4 biramous, each ramus 3-segmented, ornamented with rows of short setules, as illustrated. Spine formula for armature of distal exopodite segments of legs 1-4 – 4-4-4-3, seta formula – 4-4-4-5. Ornamentation of legs 1 – 4 as illustrated. The spines long, wide, lanceolate. The third (distal) segments of P1 – P4 endopodites bearing 6, 6, 6 and 5 setae. Distal segment of endopodite P4 slightly oval outlines; both apical setae almost identical in length; both of them a little surpass length of segment (fig. 5, *3*). P5 2-segmented, distal segment oval, its length 1.3 – 1.6 times surpass width; from its spines outer 1.1 – 1.2 times longer than inner; both spines lanceolate; apical seta (fig. 5, *4*) is hardly longer than an outer spine. Egg bags slightly divergent, reach the middle of caudal rami; contain 4 – 8 eggs each.

Male. Much more small as female (fig. 6, *1*). Hind margin of abdominal somits slightly serrated. Relative length of caudal rami is a little bit less than at female. Length of caudal setae as illustrated (fig. 6, *2*). Geniculated antennula as illustrated on fig. 6, *3*. Distal segment of endopodite P4 more massif (fig. 6, 4). At inner edge of distal segment P5 two additional setae (fig. 6, *5*). Inner small spine P6 vestigial (fig. 6, *6*), other two appendages are developed normally.

Remark. Sars [17] gives more large total length (430 – 570 μm in female) and more numerous numbers of eggs in the bag (Pl. IY).

Remarks to the differential diagnosis see in *C. esilis*.

Distribution. I have found it in 10 sites in Sea of Azov (Map 1). In this sea it was noted one time also earlier as doubtful *Cyclopina* sp. [7)] Any other representatives of *Cyclopina* from that time up to recent time often falsely determined as *C. gracilis*. The same concerns to the some of literature indications for the Black Sea. I have found *C. gracilis* in 14 geographical sites at coasts of the Black Sea, less often on Caucasian shore (Novorossiysk and Sochi).

On literature data the given species is the most often recorded (among all others Cyclopinidae) not only in the west part of the Black Sea, but in different part of the globe. According my analysis [13] it is known in the Mediterranean and East Atlantic Boreal region, in the Indo-West Pacific region (Red Sea province, Indo-Polynesian province) and also in the South-American region (as only one representative of own genus).

Ecology. Sars [17] characterized *C. gracilis* as "a strictly littoral form, being found close to the shore among algae and scarcely ever at any considerable depth". I found this species in 18 samples from the Black Sea, 11 from them was the digs in interstitial. However it is usual enough also at the bottom between macrophytes and filamentous algae, that confirms the data of other authors (Marcus, 9). According these authors it lives also on stone littoral, where it is found in more than in half of samples on depth 2 – 12 m. V. R. Shuvalov et al. [18] marked it also in hyponeistone.

Salinity preference characterizes the species as marine with the ability to adapt to some lowered salinity of the Black and Azov Seas. The Azov populations of *C. gracilis* may be characterized as pleiomesohaline (population variability). It is very demonstrative on the Map 2, where it is seen, that this species is distributed on the west shores of the investigated Berdyansk and Biruchy split in waters at salinity 11 – 11.5 ‰, but is absent on their east coasts of the same splits, where the salinity is 7 – 8 ‰ (meiomesohaline *C. hadzii* lives here). In this case we have the experiment, setting by the nature.

Cyclopina esilis Brian (fig. 7 – 9)

- *esilis* Brian, 1938: 14 (*Cyclopina*); Lindberg, 1953: 323; Vervoort, 1964: 30; Monchenko, 1979: 388; Jaume et Boxshall, 1996: 83.

Materials. Sea of Azov: 1) Arabat split by vill. Schastlivcevo Kherson reg. Genichesk district 29. III.1978, 6 females, 3 males, 1 juv. (Monchenko). 2) Berdyansk split, 9 samples in different parts of Island, depth 0.5 – 1.5 m, thickets of Zostera, filamentous algae, 4, 9, 23.VIII.1979, 149 females, 6 males, 1 juv. (Monchenko). 3) Utlyuk gulf, 21 – 27.VIII.1979, very many females, males and juv. 4) Sivash at Genichesk, 27.VIII.1979. Totally 11 sites.

Black Sea: 1) Site Potievka in Chernomorsk reservation, YIII.1971, many specimens (Monchenko). 2) Island Tendra, interstitial, 40 l, 5.VIII.1974, females 1 male (Monchenko). 3) near Odessa, interstitial, 40 l, 16. VI.1974, 7 females, 2 juv. (Monchenko). Vil. Mazhwodnoye Crimean region, 30.VIII.1974 (mass) etc. a. s.o. Totally approx. 23 sites.

Female. Total length 392 – 412 μm. First pedigerous somit with P1 is precisely isolated from syncephalon (fig. 7, *1*). Hind margines of cephalothorax smooth, of abdomen slightly serrated. The length of abdomen makes 44 – 48 % length of prosome. Genital double-somite 1.2 – 1.4 times longer than the greatest its width (fig. 7, *2*). Anal somite bearing smooth operculum. The length of almost parallel caudal rami 2.5 – 3.0 times exceeds their width (fig. 7, *3*). 10-segmented antenna (fig. 7, *4*) reaches the last third of syncephalon length. The antennula 4-segmented, with unique seta on proximal segment – a vestige of exopodite (fig. 7, *5*). Segmentation and armature of madibulare palp and maxillule palp as illustrated (fig. 7, *6*, *7*). Not clearly differentiated coxobasipodite of maxilla with 4 endites; the second exopodite segment only with two appendages (fig. 7, *8*). The maxilliped clearly 7-segmented, praecoxa and coxa isolated, endopodite 4-segmented, setal formula 0-0-1-3 with 4-segmented endopodite (fig. 7, *9*).

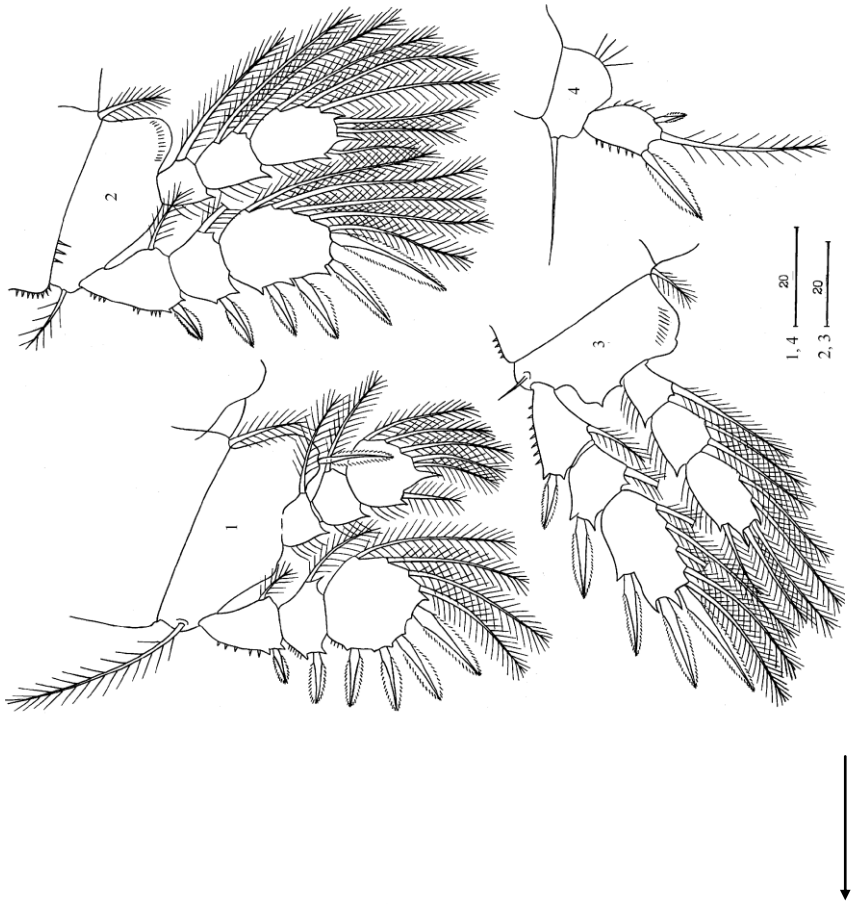


Fig. 7 *Cyclopina esilis*, ♀: *1* – habitus, dorsal; *2* – genital double-somite; *3* – caudal rami, dorsal view; *4* – antennula; *5* – antenna; *6* – mandible with the palp; *7* – maxillule with the palp; *8* – maxilla; *9* – maxilliped.

Рис. 7 *Cyclopina esilis*, ♀: *1* – общий вид, дорсально; *2* – генитальный сомит; *3* – каудальные ветви, дорсально; *4* – антеннула; *5* – антенна; *6* – мандибула со щупиком; *7* – максиллула со щупиком; *8* – максилла; *9* – максиллипеда.

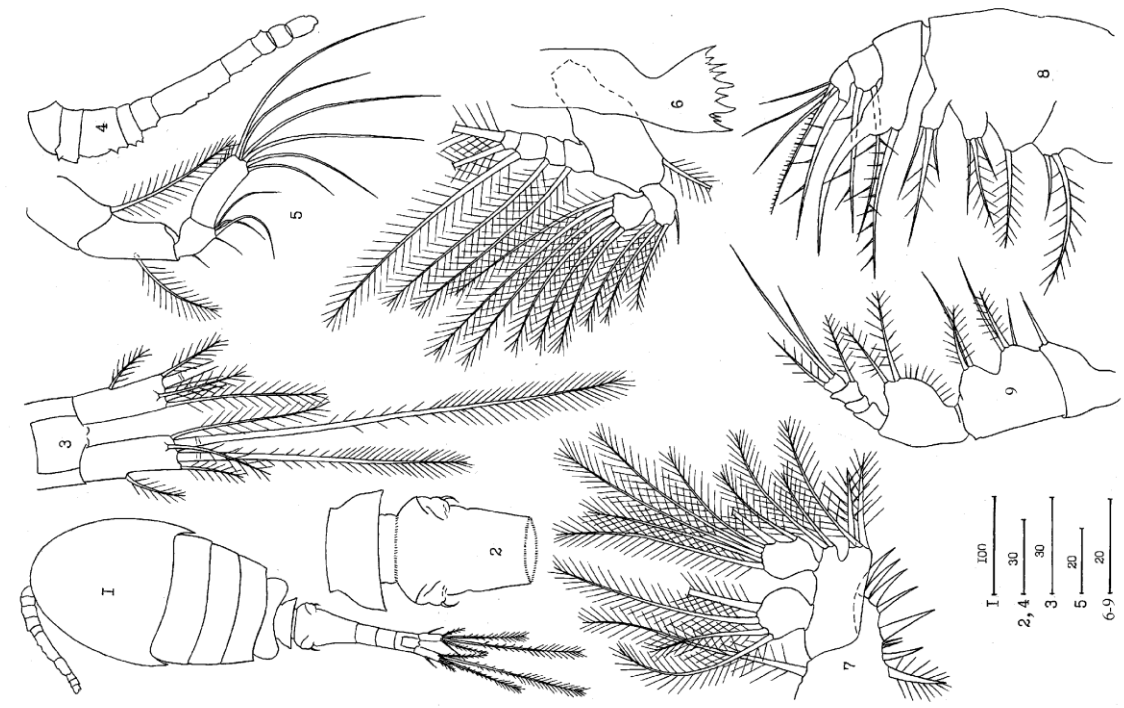


Fig. 8 *Cyclopina esilis*, ♀: *1-2* – P1 - P2, *3 – 4* – P4–P5.

Рис. 8 *Cyclopins esilis*, ♀: *1-2* – P1 - P2, *3 – 4* – P4–P5.

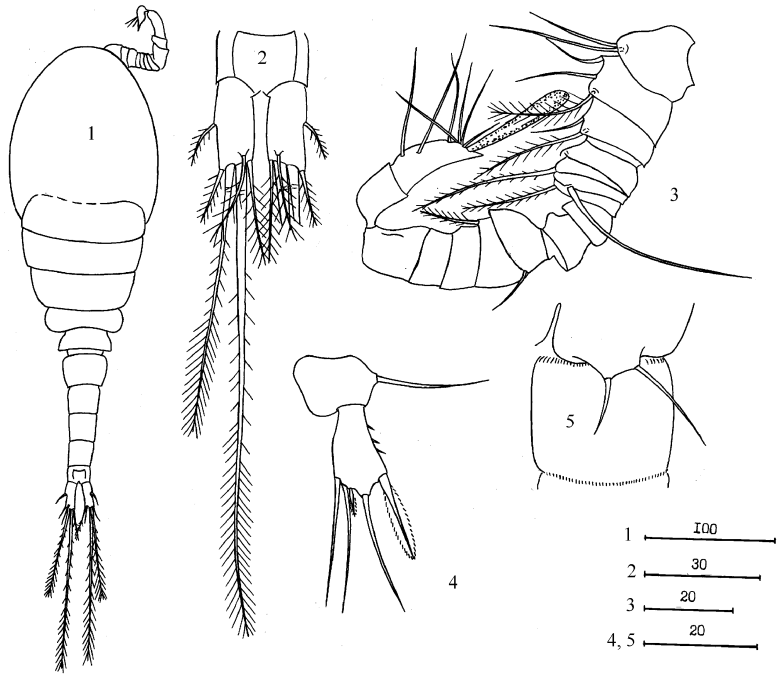


Fig. 9 *Cyclopina esilis*, ♂: *1* – habitus, dorsal; *2* – caudal rami, dorsal view, *3* – geniculated antennula; *4 –5* – P5 - P6.

Рис. 9 *Cyclopina esilis*, ♂: *1*– общий вид, дорсально; *2* – каудальные ветви, дорсально; *3* – геникулирующая антеннула; *4 – 5* – P5 – P6.

All exo- and endopodites of swimming legs biramous, both rami 3-segmented, with lanceolate spines (fig. 8, *1-3*). The spine formula 4-4-4-3, seta formula 4-5-5-5. The first segments of all endopodites and the second segment P1 with one seta, the second segments of P2-P4 – with two ones. The length of distal segment of endopodite P4 1.6 – 1.8 times exceeds width, and its apical seta approximately 1.5 times is longer than segment (fig. 8, *3*). P5 2-segmented (fig. 8, *4*); the seta of distal segment 2.2 times longer than segment and almost 2 times longer as outer spine, which in the turn 2.6 – 3.0 times is longer than inner spine. Egg bags spherical, contain 2 – 10, more often 4 – 6 eggs each.

Male. Total body length 320 – 340 μm (fig. 9, *1*). Caudal rami: length/width ratio 1.9 (fig. 9, *2)*, some its setae are shorter, than in female. Geniculated antennule 16-segmented (fig. 9, *3*). Distal segment P5 at inner edge with two additional setae (fig. 9, *4*). P6 presented by two appendages (fig. 9, *5*).

Taxonomic remarks. Comparing this redescription with the first description of the species (by Brian, 2) I must note, that the specimen of Brian differ by presence an additional seta on the second segment of antenna and absence at once several setae – on the third. The excellent redescription by Jaume et Boxshall (4) differs in some details from my illustration (fig. 9, *5*). It has an additional seta on first and last segments of antenna. On the contrary my specimens have additional seta on first endopodite segment of mandibular palp. I consider this differences have not a taxonomic significance.

As principal distinguishing feature of this species (comparing with *C. gracilis*) at first description A. Brian [2] considered the smaller dimensions of his specimens. According to him, females are 280 – 300 μm, males 260 μm (in my case females are more large – 392 – 412 μm, in average 403 μm), the males have 320 – 340 μm. In [6] the dimensions are intermediate to my specimens. The dimensions as distinguishing features used also Lindberg [8] in his table for determination of species, but already in a combination to more essential feature – sharp difference in length of both spines in P5.

It is seen, that all Black Sea females and males are distinctly larger – on the average nearby 400 and 330 μm accordingly. However I do not consider such a feature as the sufficient ground for taxonomic isolating of the Black Sea enough numerous populations. At the best case they should be considered as representatives of geographical subspecies or geographical form *Cyclopina esilis major* f. nov.

The main characteristic specific feature between two groups is a ***triple*** difference in length of spines P5. But this feature is enough indistinct without preparation. In the course of investigation of *C. esilis* I measured this species with the most allied species (type species of the genus) – *C. gracilis* and found some more distinguishing plastic features. They are important for determination because during all my history of hydrobiological investigations in the Black Sea among Cyclopinidae the most often mentioned (22 times) species were *C. gracilis* (Claus) and *C. esilis*. Now is apparently, that the part of these records is based on incorrect determination. In favour of this supposition testifies the more frequent occurrence of *C. esilis* at the coasts of the Black Sea from Odessa up to Batumi in my investigations. First from these is found in 23 samples from 23 geographical sites against *C. gracilis* was found in 22 sites (at the Caucasian coast I found exclusively *C. gracilis)*. Secondly, both of these species are on the surface similar, and deciding diagnostic feature (relative length of the spines P5) is difficultly observable without preparation on slide. In order to facilitate the determination of species I propose to use some differential plastic features of females for both species. The majority of differences are statistically significant. These data are compared in the Table 3.

Table 3 Comparison of some plastic features of *Cyclopina esilis* and *C. gracilis* (females)
Табл. 3 Сравнение некоторых пластических признаков *Cyclopina esilis* и *C. gracilis* (самки)

Features	*Cyclopina esilis* (n = 6)	*C. gracilis* (n = 10)
P5, ratio of appendages length:		
outer to inner spine	2.6 – 3.0	1.1– 1.2
seta to outer spine	1.8 – 2.0	1.1 – 1.3
Length / width ratio of caudal rami	<3	>3
Caudal setae, ratio to caudal rami length (%)		
dorsal	100 – 106 (103)	78 – 90 (82.8)
innermost	145 – 177 (163)	90 – 120 (103)
inner middle	467 – 530 (498)	342 – 400 (376)
outer middle	300 – 334 (322)	208 – 245 (227)
Ratio of some setae (%):		
innermost to outermost	188 – 200 (194)	146 – 204 (180)
middle, inner to outer	147 – 156 (153)	162 – 177 (166)
Quantity of setae on:		
First segment of antenna	1	2
First segment of mandibular endopodite	4	3
Second segment of maxilla endopodite	2	3
Egg bags	spherical	prolongated

Distribution. *C. esilis* is described from Mediterranean in the bay of Genoa [2, 20]. Other findings in this sea – at Island Mallorca [6]. The last authors suspects, that data of [4, 5] on *C. kieferi* must be considered for *C. esilis*, accordingly from Banyuls (South France) and from Brittany (North-West France). I found this species in 23 geographically sites of the Black Sea and at the first time for the Sea of Azov (from 11 sites, see a map 1). Among Cyclopinidae it is the species with the most frequency of appearance in the Black Sea [13]. This species was found by other authors near Crimean shores [22].

Ecology. Brian [2] has found this species among seaweed on depth of 1.5 m. Jaume et al. [6] found it in anchialine cave. In our samples from the Black Sea this species too prefers tangle of *Zostera*, *Phyllophora* and other seaweed. On

similar associations it is accounts 13 of 23 samples at depth of 1 – 7 m. The others (9 samples) are from interstitial with various composition – from a pure shell rests up to clean sand. In the latter case the particle can be very small (250 – 370 μm). The general salinity in the Black Sea interstitial 16 – 18 ‰, temperature 17 – 31^{0}C. The Azov populations of *C. esilis* may be characterized as pleiomeso-haline. This is very demonstrative on the Map 2, where it is seen, that this species is distributed on the west shores of the studied Berdyansk and Biruchy split in waters with salinity 11-11.5‰, but is absent on their east coasts, where the salinity 7 – 8 ‰ (here lives meiomesohaline *C. hadzii*).

Cyclopina hadzii Petkovsky (fig. 10 – 11)

– *hadzii* Petkovsky, 1955: 77 (*Cyclopina*); Monchenko, 2003: 29; – *steueri*, Plesa, 1963: 794 (*Cyclopina*); Monchenko, 1976: 844 .

Materials. Sea of Azov: 1) Arabat split by vill. Schastlivcevo Kherson reg. Genichesk district 23.VIII.1968, 1 female, 1 juv. (Monchenko). 2) Island Biruchiy, 3 samples in different parts of Island, depth 0.5 – 1.5 m, thickets of *Zostera*, filamentous algae, 27. VII.1971, 23 females, 6 males, 1 juv. (Monchenko). 3) Yasenskiy gulf by vil. Shilovka, filamentous algae, 10.VI.1978, 7 females, 1 juv. (Monchenko). 4) Dolzhanskaya split, 7.VI.1978, 2 females. Berdjansk split, 9 samples, 6, 12, 22.VIII.1979, 29 females. Totally 10 sites.

Black Sea: 1) Alushta, Rabochiy ugolok, 16. VI.1969, interstitial, 40 l, 20 females, 1 male, 11 juv. (Monchenko). 2) Island Tendra, interstitial, 40 l, 5.VIII.1971, 1 female 1 male (Monchenko). 3) near Odessa interstitial, 40 l, 16.VI.1974, 7 females, 2 juv. (Monchenko). Totally 3.

Female. Length of a body without apical seta of caudal rami 354 – 390 μm. Translucent very slender animals with wide rounded syncephalon (fig. 10, *1*). First pedigerous segment completely fused with syncephalon. Posterior edges of somits smooth. Genital double-somite with small lateral projections in the anterior part (fig. 10, *2*). The caudal rami close located to each other. The length of caudal rami 2.5 – 2.8 times more than width. Dorsal seta a little concedes in length of innermost seta which 1.8 – 1.9 times exceeds length of outermost one (fig. 10, *3*).

10-segmented antennula hardly does not reach half of syncephalon length; thin sensor cylinder on distal segment is longer than segment itself (fig. 10, *4*). 4-segmented antenna with poor armation, however with seta – a vestige of exopodite (fig. 10, *5*). Mandibular palp with 4-segmented exopodite and 2-segmented endopodite, the last segment of endopodite bearing 6 setae (fig. 10, *6*). Maxillula with rich armation (fig. 10, *7)*; with 7 setae on endopodite. Numerous rigid appendages are located on 5-segmented maxilla with only two seta on third endite (fig. 10, *8*) and it is a little of setae (only tree) on 3-segmented maxilliped endopodite (fig. 10, *9*).

P1-P4 without an ornament on baso-, coxopodites and couplers. Both rami of swimming legs 3-segmented (fig. 11, *1-3*) . The formula of spines on last segments of exopodites 4-4-4-3, setae formula 4-5-5-5. P3 is almost indistinguishable from P2 (fig. 11, *2*). The distal segments of endopodites P1-P4 bearing following number of setae: 5, 6, 6, 5 (on P1 they are very remarkable). The length of distal segment of endopodite P4 1.6 – 1.7 times exceeds width. Both apical setae are almost equal in length and a little more than 1.5 times are longer than segment itself. The length of the last segment of 2-segmented P5 2 times exceeds width; almost identical in length both subapical spines noticeably are shorter of segment itself and approximately 2 times shorter than apical seta (fig. 11, *4*).

Male. Total length 340 – 370 μm (fig. 11, *5*). Caudal rami and its setae (fig. 11. *6*), as in female. Geniculated antennula 14-segmented, with strong thickened bottleformed sensor flask on distal segment (fig. 11, *7*). Distal segment of endopodite P4 is little bit shorter, than in female, with length/width ratio 1.4. The length of the last segment P5 1.6 – 1.7 times exceeds width; it has additional lateral seta; the apical seta is relatively shorter than in female (fig. 11, *8*).

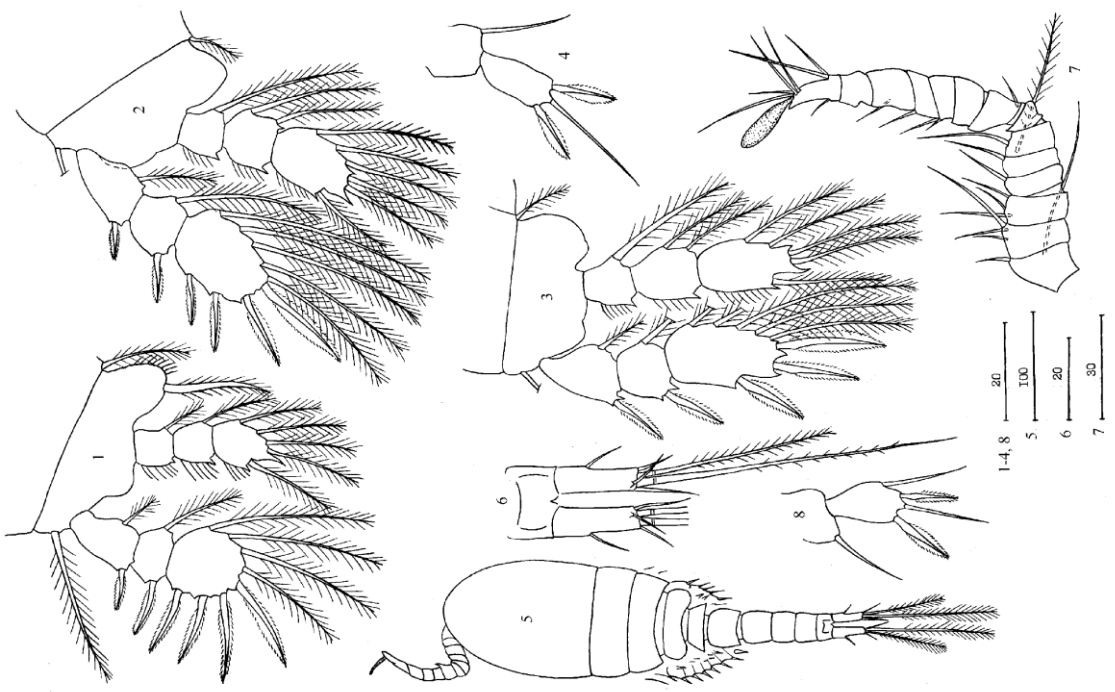


Fig. 10 *Cyclopina hadzii*, ♀: *1* – habitus, dorsal; *2* – genital double-somite; *3* – caudal rami, dorsal view; *4* – antennula; *5* – antenna; *6* – mandible with the palp; *7* – maxillule with the palp; *8* – maxilla; *9* – maxilliped.

Рис. 10 *Cyclopina hadzii*, ♀: *1* – общий вид, дорсально; *2* – генитальный сомит; *3* – каудальные ветви, дорсально; *4* – антеннула; *5* – антенна; *6* – мандибула со щупиком; *7* – максиллула со щупиком; *8* – максилла; *9* – максиллипеда

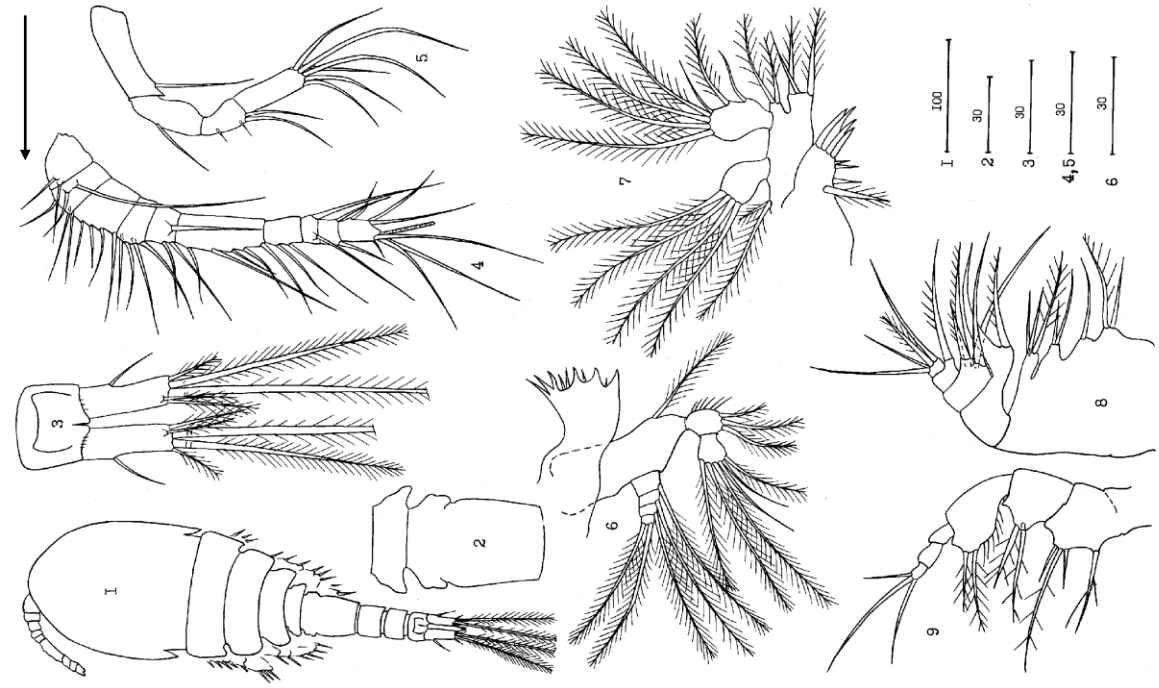


Fig. 11 *Cyclopina hadzii*, ♀: *1* – *2* – P1 – P2; *3* – *4* – P4 –P5; ♂: 5 – habitus, dorsal; 6 – caudal rami, dorsal view, 7 – geniculated antennula; *8* – P5.

Рис. 11 *Cyclopina hadzii*, ♀: *1* – *2* – P1 – P2; *3* – *4* – P4 –P5; ♂: 5 – общий вид, дорсально; 6 – каудальные ветви, дорсально; 7 – геникулирующая антеннула; *8* – P5

Remarks. The presented description of *C. hadzii* is significant more full than known previously [15]. The redescription [16] of *C. steueri* from Romanian coast I synonymize with *C. hadzii* (under question) because very characteristic armature of last endopodite segment of P1 (only 5 setae instead of 6 in all allied species), all structure of P1 – P5, very close ratio of caudal rami, ratio of distal segment of endopodite P4 etc. Deficiency of this re-description is the lack of the seta on first segment of antennule, indistinctly described mouth parts (e.g. exopodite of mandibulare palp). Superficial comparison with this redescription of Plesa led me [10] to the same mistake. Now we are sure that *C. hadzii* is a good precisely outlined species with above mentioned features (which add the poor description [15]), among them is very peculiar sensor flask on distal segment of geniculated antennule of the male.

Distribution. *C. hadzii* is known in Adriatic Sea [15], Black Sea [16]. I have found this species in 3 sites on northern part of the Black Sea and in 13 samples from different sites in the Sea of Azov. They are the first record for the last sea (see a Map 1). Thus the last sea represents for this species more favorable conditions (great number of sand and mussel rests in interstitial biotope, large splits, meiomesohaline salinity, see low) etc.

Ecology. Majority of my records of *C. hadzii* – interstitial biotope. Analogous data gives [16]. As concern to salinity, this species may be determined as meiomesohaline. This is very demonstrative on the mentioned map, where it is seen, that this species is distributed on the east shores of the investigated Berdyansk and Biruchy splits in the Sea of Azov, where salinity was 7.8 ‰ (influence of dominating north-eastern winds from river Don mouth), but is absent on their west coasts, where the salinity consists 11 – 11.5 ‰ (pleiomesohaline *C. esilis* and *C. gracilis* live here). It is also remarkable that only *C. hadzii* is recorded on eastern shore of the Sea of Azov, where salinity is lowered under the influence of powerful inflow of freshwaters of river Kuban [13]. But doing this *C. hadzii* some time was found by me in the Black Sea in 18 ‰.

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Cyclopinidae (Copepoda) в Азовском море (итоги исследования). В. И. Монченко. Представлено полное иллюстрированное монографическое описание всех видов Cyclopinidae, до исследований автора не известных в фауне моря. Впервые описаны самцы *Cyclopinoides littoralis*. Среди разных местообитаний наиболее характерным для семейства оказался биотоп интерстициаль, в котором циклопиниды обнаружены в 90 пробах из 172 взятых в 35 обследованных географических пунктах прибрежной зоны. Около 122 из них охватывают условия характерной для моря мезогалинной общей солёности. Для каждого вида приведен его солёностный преферендум (полигалинный, плейомезогалинный, мейомезогалинный). Для дифференциации азовочерноморских популяций *Cyclopina esilis major* от типовых средиземноморских и атлантических популяций *C. gracilis* (кроме более крупных размеров) предложен ряд успешных меристических признаков.

Ключевые слова: Азовское море, Cyclopinidae (Copepoda), биоразнообразие, видовые переописания, галопатия, таксономия.

Cyclopinidae (Copepoda) в Азовському морі (підсумки дослідження). В. І. Монченко. Представлений повний илюстрований монографічний опис всіх видів Cyclopinidae, які до досліджень автора не були відомі в фауні моря. Вперше описані самці *Cyclopinoides littoralis*. Серед різних місцеперебувань найбільш характерним для родини виявився біотоп інтерстиціаль, в якому циклопініди виявлені в 90 пробах із 172 досліджених з 35 географічних пунктів прибережної зони. Біля 122 з них одержані в умовах характерної для моря мезогалінної солоності. Для кожного виду наведений його соленосний преферендум (полигалінний, плейомезогалінний, мейомезогалінний). Для диференціації азово-чорноморських популяций *Cyclopina esilis major* від типових середземноморських і атлантичних популяций *C. gracilis* (окрім більш крупних розмірів) запропоновано ряд успішних мерістичних ознак.

Ключові слова: Азовське море, Cyclopinidae (Copepoda), біорізноманіття, видові нариси, галопатія, таксономія.

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